CORRELATION OF WELDING CURRENT WAVEFORM WITH WELDING CONDITION BASED ON EXPLORATORY DATA ANALYSIS (EDA)

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We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

Faculty of Electrical & Electronics Engineering
UNIVERSITI MALAYSIA PAHANG

FEBRUARY 2019

ACKNOWLEDGEMENTS

In the name of Allah, the Most Beneficent, the Most Merciful. All praises and thanks to Allah SWT for the blessings of strength and confidence that He granted me to accomplish this research successfully.

I owe my deepest gratitude to my supervisor, Dr. Hamdan Bin Daniyal for his continuous motivation, guidance and advice throughout this research. Without his constant support and help, the completion of this thesis would not have been possible. My utmost thanks to my co-supervisor, Assoc. Prof Dr. Mahadzir bin Ishak and Dr Amir Izzani bin Mohamed for all their valuable sharing and advice throughout this research.

I am deeply grateful to my parents, Mr. Mazlan bin Kasdi and Mrs. Asmawati bin Mufit for always understanding and supporting me without any hesitation. Credit also goes to my little sister, Miss Afzan Hanis binti Mazlan, who have always helped and accompanied me when I needed her. My gratitude also goes to the rest of my family who played the role to ensure my constant well-being.

To all my former co-workers from HRSB team, thank you for always being cheerful and lending me your help. A special thanks to QC Manager, Mohd. Radzi Bin Mahmood for the excellent support and guidance that he had provided throughout this research. I am also grateful to NDE Inspection Sdn Bhd, for their generous assistance.

Finally, a big thanks to all my friends and colleagues for all their cooperation and support they have so kindly extended to me which have led to the completion of my thesis. Lastly, thank you to everyone who have been involved directly or indirectly in this study. May Allah grant His blessings to all of you.

ABSTRACT

Welding is a fabrication method that is used worldwide, especially in the manufacturing and automotive industries. The conditions of the welding weldment are important to ensure the quality of the product. Hence, the quality of the product is a big concern and strict requirement to deliver a good production. Therefore, the nondestructive test like dye penetrant test, ultrasound test, and radiographic test plays the role in certifying the quality of weldment based on ASME standard. Unfortunately, the nondestructive tests are costly and time consuming. Thus, a real-time monitoring method was applied in this study. The real-time monitoring allows the test to be carried out during welding activities where the results can be obtained immediately. In previous researches, studies on real-time monitoring used the welding signal such as arc light signal, sound welding, and welding current. Among the welding signal, welding current was chosen because of its simple signals, easy to collect, and rich with information in welding process. This study was carried out by welding current signal and welding condition monitoring and produced two results. Then, both results were proceeded to manual syncing and sliced into 1 mm pieces data for high sampling data. When more data are collected, they are more precise and have more resolution. Among the current characteristics, the current's peak count is the most influential variable to correlate with the welding condition. Based on the current's peak count, the good and defect conditions can be distinguished. Next, the welding condition data and the welding current pattern were analysed using exploratory data analysis (EDA) and the findings were concluded in this study. The analysis shows that the results support the earlier findings. In this experiment, metal inert gas (MIG) welding was used and set up at the Faculty of Mechanical Engineering, Universiti Malaysia Pahang in room temperature. The outputs of the experiment were the welding sample and welding current. The conditions of welding samples were identified by a qualified person in welding. Based on the result, the welding condition and welding current were compared using manual syncing of the length waveform. Then, the data were sliced into 1 mm data and analysed on EDA. In the end, the analysis shows that there was a significant difference between the welding samples in good condition and welding sample in defect condition using current's peak count variable. This variable indicated similarities and differences between welding sample in good condition and defect condition. From the experiment, 8 out of 10 defect conditions were likely to be detected by examining the current's peak count compared to the good welding condition. Among the defects, incomplete weld and lack of penetration (LOP) defects show differences in the current's peak count whereas similar current peak count was found among other defects. As a conclusion, the welding current's peak count can identify the conditions of welding sample whether it is in good or defect condition. In the future studies, the research can be improved by exploring each of the defect types based on the current pattern with different equipment and types of metal.

ABSTRAK

Welding adalah kaedah fabrikasi di industri yang digunakan di seluruh dunia, terutamanya dalam industri perkilangan dan industri automotif. Keadaan kimpalan adalah penting untuk memastikan kualiti produk. Oleh itu, kualiti produk adalah sangat dititik beratkan dan pengawalan yang ketat untuk menghasilkan pengeluaran yang baik. Bagi memastikan kualiti kimpalan, ujian tanpa musnah digunakan berdasarkan standard ASME. Sebagai contoh, ujian tanpa musnah seperti ujian penembakan pewarna, ujian ultrasound atau ujian radiografi. Walau bagaimanapun, kebanyakan ujian tanpa musnah adalah mahal dan memakan masa. Selain itu, kaedah lain yang boleh digunakan dalam kajian adalah kaedah pemantauan semasa. Pemantauan semasa boleh di uji tanpa menghentikan proses kerja dan hasilnya akan diketahui serta-merta. Dalam penyelidikan yang lalu, kajian pemantauan semasa menggunakan isyarat kimpalan seperti isyarat cahaya arka, isyarat bunyi kimpalan atau isyarat arus kimpalan. Di antara isyarat kimpalan, arus kimpalan dipilih kerana isyarat ini mudah untuk mengumpul dan kaya dengan maklumat dalam kimpalan. Kajian ini dijalankan melalui eksperimen dan menghasilkan dua hasil; isyarat arus kimpalan dan keadaan kimpalan. Kemudian, kedua-dua hasil penyegerakan secara manual dan di bahagikan dalam 1 mm data untuk data persampelan yang tinggi. Lebih banyak data yang diperolehi maka lebih reolusi dan lebih tepat. Di antara ciri-ciri arus arus, kiraan puncak arus adalah pembolehubah yang paling berkait dengan keadaan kimpalan. Berdasarkan kiraan arus puncak, keadaan kimpalan yang baik dan keadaan kimpalan yang cacat adalah berbeza. Selanjutnya, data keadaan kimpalan dan corak arus kimpalan di analisis menggunakan analisis Penerokaan Data Analisis (EDA) dan membuat kesimpulan dalam kajian ini. Keputusan analisis menunjukkan sokongan terhadap penemuan awal dalam kajian ini. Eksperimen ini menggunakan kimpalan gas lengai logam (MIG) dan dijalankan di Fakulti Kejuruteraan Mekanikal, Universiti Malaysia Pahang pada suhu bilik. Hasil pengeluaran adalah sampel kimpalan dan arus kimpalan. Sampel kimpalan dikenal pasti oleh orang yang berkelayakan dalam kimpalan. Berdasarkan hasilnya, keadaan kimpalan dan arus kimpalan dibandingkan menggunakan penyegerakan manual bentuk panjang arus gelombang. Kemudian, kedua-dua data di bahagi kepada 1 mm data dan di analisis menggunakan Penerokaan Data Analisis (EDA). Akhirnya, analisis menunjukkan terdapat perbezaan yang ketara antara sampel kimpalan dalam keadaan baik dan sampel kimpalan dalam keadaan cacat menggunakan pembolehubah kiraan puncak arus. Pembolehubah ini menunjukkan persamaan dan perbezaan antara sampel kimpalan dalam keadaan baik dan keadaan kecacatan berdasarkan kiraan puncak arus.Daripada eksperimen, 8 daripada 10 jenis kecacatan adalah sangat dapat di kenalpasti melalui pemeriksaan ke atas kiraan puncak arus. Antara kimpalan dalan keadaan cacat, kimpalan yang tidak lengkap dan kekurangan penembusan (LOP) menunjukkan perbezaan pada kiraan puncak arus manakala jumlah puncak arus yang sama didapati di kalangan keadaan kimapan cacat yang lain. Akhirnya, kiraan puncak arus kimpalan dapat mengenal pasti sampel kimpalan adalah keadaan yang baik atau mengandungi keadaan kimpalan yang cacat. Dalam kajian masa depan, penyelidikan boleh diterokai untuk setiap jenis kecacatan kimpalan berdasarkan bentuk arus dengan peralatan yang berlainan dan pelbagai jenis logam.

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LIST OF SYMBOLS

A	Ampere
V	Volt
mm	Milimeter
MHz	Mega Hertz
CO_2	Carbon dioxide
s	Second
k	Boltzmann constant
K	Kilo

LIST OF ABBREVIATIONS

MIG	Metal Inert Gas
GTAW	Gas Tungsten Arc Welding
PAW	Plasma Arc Welding
SMAW	Shielded Metal Arc Welding
NDT	Non-destructive Test
RT	Radiography test
DPT	Dye-penetrant Test
VI	Visual Inspection
MPT	Magnetic Particle Test
UT	Ultrasound Test
AC	Alternating current
ASME	American Society Mechanical Engineering
API	American Petroleum Institute
AWS	American Welding Society
LOP	Lack of penetration
LOF	Lack of fusion
STE	Short Time Energy
EDA	Exploratory Data Analysis
ANOVA	Analysis of variance
WEDM	Wire electrical discharge machining
RMS	Root mean square

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